



**ASSESSING COASTAL  
DEVELOPMENT ALONG  
RACINE COUNTY'S  
LAKE MICHIGAN  
SHORELINE:  
1978 - 1992**

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**THE WISCONSIN COASTAL MANAGEMENT PROGRAM**, part of Wisconsin Department of Administration, and overseen by the **WISCONSIN COASTAL MANAGEMENT COUNCIL**, was established in 1978 to preserve, protect and manage the resources of the Lake Michigan and Lake Superior coastline for this and future generations.

**The Project Team**

This project required coordination and completion of several steps including map documentation, photo preparation, photo interpretation, digital area/linear measurement and data sheet preparation. The following students worked as a team to help complete this project.

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## TABLE OF CONTENTS

INTRODUCTION . . . . .	1
PROJECT GOALS . . . . .	1
STUDY AREA . . . . .	1
PROJECT METHODS . . . . .	3
Aerial Photography . . . . .	3
Project Aerial Photos . . . . .	4
Photo Preparation . . . . .	4
Aerial Photo Interpretation (API) . . . . .	5
CLASSIFICATION SCHEME . . . . .	5
Residential Land . . . . .	5
Commercial and Industrial Land . . . . .	6
Industrial Land . . . . .	7
Transportation Land . . . . .	7
Extractive Land Use . . . . .	8
Agricultural and Natural Land . . . . .	8
Open and Other Land . . . . .	10
Shoreline Modification . . . . .	10
Structures - Industrial, Commercial and Residential . . . . .	11
THE PHOTOINTERPRETIVE PROCESS . . . . .	11
MEASUREMENT OF AREA, LINE AND POINT TYPES LOCATED WITHIN THE COASTAL ZONE . . . . .	12
TALLY OF DATA . . . . .	12
LIMITATIONS AND SOURCES OF ERROR . . . . .	13
Photo Scale and Enlargements . . . . .	13
"Leaves-On" Versus "Leaves-Off" Aerial Photography . . . . .	14
Stereo Versus Photographic Coverage . . . . .	14
Incomplete Photo Coverage . . . . .	14
Missing Photo Coverage . . . . .	15
Location of 1000' Coastal Zone Boundary . . . . .	15
Lack of Beach Type in Classification Scheme . . . . .	15
Positional Changes to the Shoreline: Natural vs. Urban Development . . . . .	15
RESULTS . . . . .	16
Racine County Statistics . . . . .	16
Residential Land . . . . .	18
Commercial and Industrial Land . . . . .	18
Transportation Land . . . . .	18
Extractive . . . . .	18
Agricultural and Natural Land . . . . .	19
Open/Other Land . . . . .	19
Shoreline Modifications . . . . .	19
Results by Community . . . . .	20
Town of Caledonia . . . . .	20
Town of Mount Pleasant . . . . .	20
Village of North Bay . . . . .	21

City of Racine . . . . .	22
Village of Wind Point . . . . .	22
REFERENCES . . . . .	24
APPENDIX . . . . .	28
LIST OF TABLES	
Table 1. County Results of Linear Accuracy Tests . . .	17
LIST OF FIGURES	
Figure 1. Coastal Counties of Lake Michigan and Lake Superior . . . . .	2

**Assessing Coastal Development Along Wisconsin's  
Great Lakes Shoreline: 1978 - 1992**

Coastal Management Program Contract No. 840005-501.15

**INTRODUCTION**

The Wisconsin Coastal Management Program mission includes developing an understanding of change along the state's Great Lakes shoreline. Such change, of course, can be natural or human-based. This study was undertaken to document natural and human-based development within the coastal zone of the state's Lake Michigan and Lake Superior shorelines. The Wisconsin legislature has defined coastal zone as land within 1,000' (304.8 meters) of the shoreline (Ordinary High Water Mark - OHWM).

Future coastal zone planning and risk assessment requirements defined the types of data to be collected. Assessment of risk to structures built in the coastal zone requires a temporal analysis of structural development and shoreline modification(s). Planning of the coastal zone requires, as well, determination of the natural resource base. This study utilized U.S. Army Corps of Engineers historic color aerial photographs taken in 1978 and 1992.

This report documents both the original and amended contract to assess natural and developmental change within the coastal zone of Wisconsin's Great Lakes shorelines. Although the original contracted work was interrupted to include elements of the amended contract, no attempt will be made in this report to keep separate original vs. amended objectives, procedures or results. Goals of the amended contract include and expand those of the original.

**PROJECT GOALS**

Planning and assessment of hazards within the coastal zone defined the goals of this study. Within the Lake Michigan and Superior coastal zones, project goals included:

- Development of land use databases for 1978 and 1992
- Development of 1978 and 1992 databases of human modification of the shorelines
- Develop a database of built structures for 1992

Additional goals included:

- Assess land use change within the coastal zone from 1978 to 1992
- Assess human modification of the shoreline from 1978 to 1992

**STUDY AREA**

The project study area comprises the Wisconsin portion of the Lake Michigan and Lake Superior coastal zone (Figure 1). In 1982, the Wisconsin state legislature defined coastal zone as being that land within 1,000 feet (304.8 meters) of lake shoreline. Accordingly, the study area represents a 1,000' wide



Figure 1. Coastal Counties of Lake Michigan and Lake Superior

examine urban development into coastal wetlands (Niedzwiedz and Batie, 1984).

#### Project Aerial Photos

In 1978, the U.S. Army Corps of Engineers (USACE) obtained panchromatic color aerial photos of the Wisconsin portion of the Lake Michigan coastline. In 1992, USACE obtained color aerial photo coverage of the Wisconsin portion of both Lake Superior and Lake Michigan coastlines. Both the 1978 and 1992 photos were flown at a scale of 1:6000 (1" = 500') and enlargements made at 1:2400 (1" = 200'). The 1978 photos were taken April 16<sup>th</sup>. The 1992 photos were flown May 13<sup>th</sup>.

Unlike most historical aerial photos covering the same area and flown at the same scale, the USACE photos of 1978 and 1992 were not flown with coincident photo centers or coverage. No individual flight lines were documented for the 1978 photos. Beginning at the Michigan border, the 1978 photos were taken incrementally to the Illinois border. Photos are documented with the photo date and photo number on the northern edge of each photo.

Flight lines were documented for the 1992 photos. Flight line #1 begins just south of the Wisconsin-Illinois border. The northern edge of each 1992 photo displays the photo date, flight line and photo number.

Both the 1978 and 1992 photo contact prints (1:6000) were flown to produce stereo coverage of the coastline. Adjacent photos overlap (endlap) about 60% with each other. The enlarged photos (1:2400) available for this study represent every other photo contact print, therefore, only photographic, not stereo coverage, is provided by the enlarged photos. Approximately 1,800 photos (1:2400) cover Wisconsin's Lake Michigan shoreline, 900 for each flight year. About 1,200 photos covering the shoreline from Marinette to Sheboygan are on file at the Green Bay office of USACE. The Waukesha office of USACE has on file about 600 photos covering the shoreline from Sheboygan to the Illinois border.

#### Photo Preparation

Photos used in this study are owned by USACE. As a result, all photo documentation and interpretive work was applied to acetate affixed to each photo. Preparing photos for interpretation included the following:

1. Affix label and document photo number/flight line, photo date and Public Land Survey System (PLSS) information.
2. Mark photo fiducials (orange ink). Fiducials allow the registration of acetate overlays to the photos, if required.
3. Mark control points (orange ink). Typically these points are road intersections and/or buildings, stable objects

that could be referenced against controlled maps for future mapping applications.

4. Locate and mark interpretation boundary lines (black ink). These lines are used to denote a common boundary between adjacent photos. Land use interpretive lines end at these boundary lines, which eliminates redundant interpretive work.
5. Locate, mark and label PLSS section lines (red ink).
6. Locate, mark and label civil boundary lines (green ink).
7. Locate and mark 1,000' coastal zone boundary line (blue ink). A divider was used to scribe a line 1000' away and parallel to the line defined by land meeting water. In cases where large streams entered Lake Michigan, a straight dashed line was drawn to represent a continuation of the shoreline.
8. Locate and mark top of bluff, and bottom of bluff if slumpage is evident (black ink). In practice, these lines were not drawn until the shoreline portion of the classification scheme was applied to the photos. Refer to the section Photointerpretive Process (page 11) for additional discussion.

#### Aerial Photo Interpretation (API)

The landscape within the coastal zone can represent a complex mix of natural to urban uses. The land use classification scheme developed for this study addresses the complexity of Wisconsin's coastal zone. The scheme is a modification of the scheme developed by International Joint Commission (1993) and includes the general use categories of residential, commercial, industrial, transportation, extractive, agricultural, natural, open land and other uses. Land uses have been measured by area (acres, hectares). Structures per land use have been located and marked for spatial reference. Structures are tallied by type for 1992.

Modification of the shoreline also has resulted. Sea walls, revetments, groins and permanent docks have been constructed. Sea walls and revetments are linear types. Their interpretation and measurement are presented in feet (meters). Groins and docks were counted.

#### CLASSIFICATION SCHEME

##### Residential Land

All residential areas include infrastructure to service the area. Boundary placement is made to separate residential areas by type. No attempt is made to distinguish roads/streets from the residential areas they serve. This convention is true for other classification types as well.

- 111 Multi-Family: Medium to High Rise. Large residential structure of five (5) or more stories. Access roads, parking areas, open space and recreational facilities associated with the structure(s) would be included in the type.
- 112 Multi-Family: Low Rise. Large residential structures up to four (4) stories. Access roads, parking areas, open space and recreational facilities associated with the structure(s) would be included in the type.
- 113 Single Family, Duplex. Structures large and small used for residential use. The type includes lawn, landscaped areas, garage and driveways. Duplex structures are identified by twin driveways or a very wide driveway leading to an architecturally balanced structure.
- 115 Mobile Home Park. Residential area developed exclusively for mobile units.

#### Commercial and Industrial Land

Commercial land includes three (3) types: central business district; shopping center/mall; and, neighborhood business district. Each type includes all building structures, access roads/streets, parking facilities and other features commonly associated with each type.

- 121 Central Business District (CBD). Commercial land predominantly used for distribution or merchandizing of goods and services. Stores, hotels, office buildings, parking facilities and smaller warehouses constitute the components of this type. The CBD spatially is tight, vegetation is rare.
- 122 Shopping Center/Mall. These commercial areas have developed away from the CBD. The type includes both "strip" type development and malls. Structures can range from large, flat roofed and rectangular (centers) to large, geometrically shaped. Both types include large parking areas adjacent to or completely surrounding the commercial structures.
- 124 Neighborhood Business District (NBD). This type denotes small commercial areas within, or adjacent to residential areas. The type may be found in established or newer subdivision areas. NBD structures can range from conventional architecture to unusual geometric shapes. Small parking areas are associated with NBD commercial areas.

- 126 Institutional Land. The type reflects areas devoted to public or quasi-public uses. Examples include schools, churches, hospitals, prisons, etc., and their associated "grounds," green space, landscaping and parking facilities. When located within the CBD, public buildings without "grounds" often cannot be identified on aerial photos and would be classified as commercial (121).

#### Industrial Land

- 138 Industrial Park. The type includes both heavy and light industrial use areas.

Heavy industrial land contains facilities for the manufacture, storage and assembly of raw or partially processed products such as machinery, metals, chemicals, petroleum, or electrical power. Such industries often have large smokestacks and large storage areas. Warehouses and transportation facilities for bulk products and an open and interrupted street pattern characterize this type.

Light industrial land contains facilities for the manufacture or assembly of smaller, partially processed products such as electronics, appliances, and other secondary process products. Large smokestacks or raw material storage facilities are never present. Many modern light industries are well landscaped and are indistinguishable from commercial activity on aerial photographs.

#### Transportation Land

- 141 Air Transportation. Includes areas with airports and associated facilities, landing strips, hangers, parking areas and adjacent open areas.

- 142 Rail Transportation. This type includes railyards, terminal freight and storage facilities as well as stations for passengers. The type may include liquid storage facilities such as tank farms.

- 143 Water Transportation. This designation is applied to several water-based areas, including docks, warehouses and related land-based facilities for water transportation and commercial fishing. The type includes, as well, public marinas and their associated facilities: boat slips, buildings and parking areas.

- 143.1 Private Marina. Boat mooring areas adjacent to residential land are designated as private marinas. Often such areas include a protected slip(s), dredged waterway and, or a permanent docking structure built into the waterway.

- 143.2 Public Boat Landing. This type is applied to boat launching areas. Typically, facilities include only a ramp(s) from which boats may be launched and parking areas.
- 144 Divided Highway. This type includes transportation corridors with median strips between lanes. Typically, such roads are four or more lanes wide. Local streets are not included in this type.
- 145 Communications. Facilities and structures devoted to communications. These include radio/television towers, lighthouses and their grounds, buildings and parking areas.
- 146 Utilities. This type includes facilities for the production and distribution of energy. Such areas can include large buildings, towers, roads/parking facilities and, in the case of coal fired plants, large piles of raw coal.
- 147 Sewage Treatment Plant. Buildings, treatment lagoons, parking areas, access roads and grounds are included in this type.
- 148 Landfill. Landfill sites used to bury garbage define this type. Landfills cover an extensive area and are dominated by large excavated areas, mounds of exposed soil and access roads.

#### Extractive Land Use

- 171 Open Pit. The type represents open pit mining areas for extraction of sand, gravel, stone or rock. The type includes access roads and any structures.
- 172 Underground Mine. Mining of underground resources via shaft extraction. Surface features captured on aerial photos would be limited to small structures and access roads.
- 173 Well. Features associated with wells are limited. Identification of wells using only aerial photos is difficult.
- 179 Other Extractive Uses.

#### Agricultural and Natural Land

- 181 Abandoned Field (AF). These are agricultural units reverting to wild land. Woody vegetation and grass are abundant but tree crown cover is less than 30%. If tree crown cover were greater than 30%, the land would be classified as forest.

- 182 Agriculture Active (AG). Tilled or tillable crop land which is or recently has been intensively farmed. The boundaries on the ground usually are sharply defined and well maintained. The land supporting farm buildings is included as part of this type.
- 183 Forest (F). Areas of forest, deciduous, coniferous or mixed, having canopy closure of at least 30%. Areas with less than 30% canopy closure are classified as abandoned field.
- 184 Heath (H). Areas of heath plant community as well as grass, shrubs, and other low vegetation found on poor sandy soils.
- 185 Open Water (W). Areas of open water found in lakes, rivers and large streams. Water depth is greater than three feet during the growing season. The boundary of coastal water is located by drawing a line at the river mouth to connect the edges of the coastline, or man-made features like roads, railroads or bridges crossing rivers or inlets are used to establish such a line.
- 186 Rock Ledge (RL). Rock outcrop areas at the coastline or within the coastal zone. Such outcrops are common in Door County.
- 187 Slump Zone (SL). Land located between upland bluff and beach. Slump zones begin at the bluff line and slope down to the beach.
- 188 Wetland (WT). This type covers the full spectrum of wetlands. These include seasonally flooded flats, shrub swamps, meadows, bogs, shallow and deep marshes, and forested wetlands. Each is described below.
- Seasonally flooded basins or flats occur principally on stream floodplains. The most common plants are grasses and herbaceous species. The soil is waterlogged or covered with water during spring freshets, but well-drained during the growing season.
- Shrub swamps often have waterlogged soil during the growing season, as much as six (6) inches of water may be present. Vegetation types include elder, buttonbush, dogwood and willow. Sedges usually are present in tussocks.
- Meadows are vegetated with grasses, rushes and sedges. Soils are waterlogged through most of the growing season. Surface water is present only for a short period during the spring.
- Bogs are unique wetland types that support a distinctive plant community, including most of the following: heath shrubs, cranberries, pitcher plants and sedges. Scattered black spruce, tamarack and red maple may be present. A mat of sphagnum moss is the most common feature of bogs.

Shallow marsh is wetter than meadow. The soil is completely waterlogged and often covered with up to six inches of water during the growing season. The predominant vegetation is emergent, including such plants as cattails, bulrushes, burreed, pickerelweed and arrowhead with some grasses and sedges present. The type is common to open water bodies.

Deep marsh has water depth ranging from six inches to three feet. Fairly large open water areas are bordered by, or interspersed with, emergent vegetation like that found in shallow marsh. Floating and submergent plants such as water lilies, duckweed, watershield and pondweeds also are present.

Forested Wetlands. This type represents areas of moist to saturated soil covered by forest canopy. The type is difficult to identify without stereo photography and, or with "leaves-on" photography.

#### Open and Other Land

##### 191 Outdoor-Public Assembly

192 Urban Open Lots. Urban open is undeveloped land lying idle in the midst of urban areas or adjacent to them. This type includes land which has been cleared for urban development of an unknown use.

193 Outdoor Recreation. Outdoor recreation types are either mainly for participation, mainly for spectators, or are environmental in character. Each recreational type includes the recreational complex: access roads, parking facilities, buildings and other related facilities.

##### 194 Cemeteries

#### Shoreline Modification

Development along the lakeshore often means modification at, or near, the shoreline. Land along the lakeshore is exposed to significant erosional forces. Recession of land mass is common. Agricultural and urban land uses destabilize shoreland, in effect accelerating erosion and land recession. To protect real estate and property, many property owners have constructed walls or revetments along their shoreline. Some owners also have built non-flow-through docks at the shoreline to provide mooring and protection for their boats. Groins, large rock structures perpendicular to the shoreline, have been built along Wisconsin's Lake Michigan shoreline.

195 Sea Walls (V 195 V). These structures are built parallel to the shoreline and typically are well defined, linear

features. Construction materials can include concrete, wood or interlocking sheet steel.

- 196 Revetments (V 196 V). Large rock or slab structures built parallel to the shoreline. Interpretively, revetments are less well defined, and appear wider than do sea walls.
- 197 Groins ( \* [red] ). Groins are large rock structures built perpendicular to the shoreline into the water. Except for their distinct orientation and placement, groins appear similar to revetments.
- 198 Non-Flow-Through Dock ( \* [blue] ). Such docks are permanent structures built into near-shore waters. Typically these docks are straight, their upper surface wide and well defined.

#### Structures - Industrial, Commercial and Residential

On the 1992 photos, buildings within the coastal zone are classified by type and location. Using a template of rectangles, for each building, a rectangle is selected that best represents the area of the building's "footprint." The selected rectangle then is positioned so that the leading edge of the building (relative to the shoreline) is located. Green ink was used to represent commercial/industrial/institutional buildings while red ink was used for residential buildings.

#### THE PHOTOINTERPRETIVE PROCESS

After photo preparation, each photo was interpreted using the classification scheme defined above. Area (land uses), linear (shoreline modification) and point (urban structures, groins, docks) types are represented in this study. Lines and, or symbols were used to define all types. Area types are represented by perimeter boundary lines and symbols to define and identify the areas. Line types representing modification to natural shoreline were defined using both lines and symbols. All area and line type symbols are recorded in black ink. Point types are defined by symbols and colored ink (see above).

Modifications to the shoreline, such as sea walls or revetments, are delineated by placing (painting) the 'V' symbol at the beginning and end of the modification. The type of modification is represented by placing the appropriate number between the 'V' symbols. For example, 195 positioned between two 'V' symbols means that a sea wall has been built along this section of shoreline. Shoreline classification was conducted before land use so that land use boundary lines placed along the shoreline would not 'hide' shoreline information.

Groins and non-flow-through docks were defined by point symbols (see above). In both cases, the symbol was placed at the point where the structure meets land. As discussed above, for

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1992, buildings also were classified using point symbols. The delineation of buildings represents the last API procedure.

#### MEASUREMENT OF AREA, LINE AND POINT TYPES LOCATED WITHIN THE COASTAL ZONE

Area types (land use polygons) and line types (shoreline modification) measurements were made using the hardware/software facilities of the GIS Lab at the University of Wisconsin-Green Bay. Photo acetate overlays were affixed to large-format digitizers and each land use polygon digitized along the perimeter. Measurements recorded in square inches were converted to acres/hectares. Line measurements (in inches) of shoreline modifications were made using digitizers as well. Linear inch measurements were converted to linear feet/meters for each type of modification.

Point types (groins, structures) simply were tallied by count for each type. The area covered by each acetate was broken into civil jurisdiction and PLSS section designations. Measurements (above) were separated by civil and PLSS designations as well, and documented permanently on each acetate overlay.

#### TALLY OF DATA

Measurements recorded on each photo acetate were transferred to data sheets. Three (3) levels of data sheets were used: PLSS Section Data; Civil Jurisdiction Summary Data; and County Summary Data (Appendix).

PLSS Section Data Sheet: One (1) PLSS Section Data sheet was used for each section located on a photo/acetate. Generally, 1-2 PLSS sections are located on a photo, however, up to four (4) sections per photo were recorded. Section level data sheets record photo documentation including photo year, photo number, county and community(ies) covered, and complete PLSS section location. Also recorded were number of residential, commercial, industrial and institutional structures (1992), area of land use by type, linear distance of sea walls and revetments, and the number of groins and non-flow-through docks.

Civil Jurisdiction Summary Data Sheet: This tally sheet summarizes the data for all PLSS section sheets found within each township, village or city. The sheet records photo year, county, name of civil jurisdiction, a complete listing of PLSS sections included in the summary, as well as all land use, shoreline and structure count data discussed above.

County Summary Data Sheet: The County Summary sheet summarizes all data for the towns, villages and cities located within the county. Documented information includes photo year, county name, an alphabetical listing of all civil jurisdictions within the county, and a summary of all land use, shoreline and

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structure count data reported on Civil Jurisdiction Summary Data sheets.

#### **LIMITATIONS AND SOURCES OF ERROR**

The U.S. Army Corps of Engineers contracted for aerial photography of the Wisconsin portion of the Lake Michigan shoreline on April 21, 1978 and May 19, 1992. Both sets of photos are 1:6000 scale and panchromatic color, however, the 1978 photos are "leaves-off" while the 1992 photos are "leaves-on."

Copies of the original stereo photos (1:6000 scale) were not available for this study. Instead, enlargements (1:2400 scale) of the original photos were borrowed from Corps district offices in Green Bay and Waukesha. The enlargements provided photographic coverage only, not stereo coverage. Normally, for a project of this magnitude, photos would have been taken to meet the specific objectives of the study. The enlarged photos used for this project present limitations and introduce error beyond what would be reported with original photos flown specifically for this study. Limitations and errors associated with the photographs used are discussed below. Also presented below is discussion regarding methodological inconsistencies.

The following discussion of Limitations and Sources of Error is presented in an attempt to provide the reader a basic understanding of the issues. Any section of the discussion could apply to any of the results reported below. The Results sections of this report present findings without any comprehensive attempt to explain anomalies within, or between, the photo study years (1978 and 1992).

#### **Photo Scale and Enlargements**

All vertical aerial photographs not ratioed (enlarged or reduced to a common average scale) or rectified (common tilt/tip corrected to a horizontal reference plane) inherently are scale inaccurate. The original USACE photos (1978 and 1992) were not ratioed or rectified, therefore, their scale varies relative to topographic changes of the coastal zone, tip/tilt of the camera and changing elevation of the camera (aircraft). Enlargements of the original photos simply accentuate the inaccuracies found on the original photos.

Area and linear measurements taken off of the USACE enlarged photos reflect the inaccuracies inherent in those photos. Simple tests of shoreline distances for numerous PLSS sections within each county were conducted to establish linear accuracies of the photos. USGS topo sheets at 1:24000 scale were used to establish base shoreline distance measurements against which photo (1978 and 1992) shoreline distance measurements could be compared. No systematic errors were detected for the 1978 photos. However, only one (1) of 21 tests of the 1992 photos varied in the positive direction from USGS measurements. The remaining 20 tests varied in the negative direction and ranged from -0.8% to

-13.1%. The range of error, for 1978 was -5.3% to +9.6%, while the range of error for 1992 was -13.1% to +1.9% (see Table 1 page 17). Without a test of error for each photo used, there is no means to judge the direction or the amount of error relative to statistics associated with each photo. However, given the range of error found for the 1978 and 1992 photos, it is possible that 1,000 acres (405 ha) (actual) of coastal zone area could be reported as 1,096 acres (444 ha) in 1978 and 869 acres (352 ha) in 1992, a 227 acre (92 ha) difference.

#### **"Leaves-On" Versus "Leaves-Off" Aerial Photography**

There are distinct advantages and disadvantages of both "leaves-on" and "leaves-off" aerial photography. However, given the goals of this project, the 1978 "leaves-off" photography offers important advantages over the 1992 "leaves-on" photography. Vegetation in leaf can hide the details of built structures, including buildings and shoreline modifications. Roads can be hidden under tree crowns, as well as portions of lots landscaped and managed as residential land. Leaved canopies increase the effect of shadows. Shadows mask ground, understory and structural information leading to inaccurate interpretation. Land uses and/or structures hidden under the canopy of vegetation or masked by shadows can be underestimated in area, length or count. Land use types particularly affected (underestimated) are single family residential and wetland.

#### **Stereo Versus Photographic Coverage**

Both the 1978 and 1992 photo sets were taken to capture stereo (3-D) coverage of the Lake Michigan coastal area. This means that adjacent photos overlap approximately 60%. Stated another way, 60% of the shoreland area located on one photo also is located on an adjacent photo. The shoreland common to adjacent photos is "seen" from two different perspectives which allows stereo viewing (using a stereoscope).

The enlarged photos borrowed from USACE for this study represent photographic coverage only, or every other photo taken of shoreland. While photo (2-D) coverage at large scales can be used to interpret accurately many land use types (agricultural and most urban land), the lack of stereo viewing makes difficult the identification of wetland types and the exact location of bluff lines. Stereo viewing generally would have increased the interpretive accuracy of most land use, structural and shoreline features.

#### **Incomplete Photo Coverage**

For this study, the coastal zone is defined as a 1000' strip of land adjacent and parallel to the shoreline. Occasionally, photo coverage did not include all shoreland within 1000' of the water. As a result, total land area is underrepresented, the

exact land use types not covered are not known. In such cases, the area not captured on a particular photo was estimated by reference and comparison to coverage photos of the other flight year.

#### Missing Photo Coverage

Occasionally, photo coverage was missing from the USACE photo library. In such cases, as described above, coverage area missing was estimated by reference to photos of the other flight year. However, the exact land use types and shoreline features not represented on photos remain unknown.

#### Location of 1000' Coastal Zone Boundary

On each photo set, 1978 and 1992, a boundary line was drawn representing the 1000' coastal zone parallel to the shoreline. This line was located by scribing a landward line parallel to the line defined by the shoreline (where water meets land). The landward extent of the boundary line is a function of shoreline location, which in turn, is dependent on the water elevation of Lake Michigan. USACE (1978, 1992) reports that in April of 1978 Lake Michigan water elevation was about 578.4 feet (176.3 meters) and about 579.16 feet (176.5 meters) in May, 1992. The nine (9) inch difference in water elevation, while seemingly insignificant, could have shifted substantially landward the shoreline in extremely low slope beach or mud flat areas. The result of such a shift would be inclusion of inland areas NOT included in the 1978 coastal zone.

#### Lack of Beach Type in Classification Scheme

The width or extent of beach is dependent on slope of an area and water elevation. Since changes in the area of beach likely would reflect more the differences in 1978 and 1992 water levels (9 inches higher in 1992) than actual losses/gains due to erosion or development, no beach type was included in the study.

The lack of a beach type does affect measurement of area within the 1000' coastal zone. The landward extent of the coastal zone is 1000' from the shoreline. Any beach area lies between the shoreline and the base of the bluff, however area measurements of land use types were made only for those types lying between the base of the bluff and the interior boundary of the coastal zone. In most cases, beach strips represent only about five (5) acres per photo.

#### Positional Changes to the Shoreline: Natural vs. Urban Development

As discussed above, the landward extent of the 1000' coastal boundary is dependent on the location of the shoreline. Natural changes to shoreline position include both water elevation and

erosion/deposition of soil. Filling of coastal waters to accommodate urban development artificially changes shoreline location. In such cases, not only does the shoreline move "offshore," the interior coastal zone boundary line shifts toward the water. This "shift" in coastal boundaries skews area measurement. For example, in 1978 assume the coastal zone in an area to be all residential and that by 1992 100 acres of lake water is filled to develop commercial land. A "lakeward" shift in the location of the shoreline will occur due to the land filled for commercial use. However, this "shift" in the shoreline created by the filled commercial site also will result in a shift toward the water of the interior coastal zone boundary. The effect of the latter shift will be that 100 acres of residential land will not be included as part of the 1992 coastal zone. In such a case, the "raw" statistics misleadingly suggest that 100 acres of residential land use were eliminated to make room for 100 acres of commercial use.

## RESULTS

### Racine County Statistics

Racine County communities lying within the Lake Michigan coastal zone include the townships of Caledonia and Mount Pleasant, the villages of North Bay and Wind Point, and the city of Racine. The area measured within the coastal zone of Racine County was 1,649 acres (668 ha) in 1978 and 1,590 acres (643 ha) in 1992. This represents a difference of 59 acres (23.9 ha) or 3.6%. The discrepancy likely is the result of errors inherent in the enlarged aerial photos, as discussed on pages 12 through 15. Using USGS maps as control, tests were conducted on the linear accuracy of the Racine County photos. Results of tests applied to the 1978 photos indicate a range of error from -3% to +2.2%. However, results of tests applied to the 1992 photos indicate errors of -.8% to -5%.

Statistical summaries for Racine County and all communities included in this study are located in the Appendix.<sup>1</sup> Summary data sheets present land use types by area, structural counts by type (1992), shoreline modification types by length, and a count of shoreline structures by type. Data were collected at the PLSS section level. While the section level data sheets are not included in this report, copies are available upon written request.

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<sup>1</sup>Area figures used in the Results discussion reflect totals (not rounded) reported on the original tally sheets. Figures presented on the tally sheets found in the Appendix of this report have been rounded to the nearest whole number.

Table 1. County Results of Linear Accuracy Tests

Percent Deviation From USGS Base Map Measurements

<u>County</u>	1978 Enlarged Photos (1:2400)	1992 Enlarged Photos (1:2400)
Brown	-0.4% 0.03%	-8.5% -5.5%
Door	1.3% 3.9%	-1.1% -3.6%
Kenosha	-2.5% 3.1%	-9.0% -1.6%
Kewaunee	-1.5% 2.1%	-5.4% -9.6%
Manitowoc	-1.7% 2.0%	-6.4% -7.4%
Marinette (one test)	9.6%	-1.7%
Milwaukee	-4.9% -5.3%	-6.9% 1.9%
Oconto	2.9% 8.5%	-10.8% -13.1%
Ozaukee	0.2% 1.3%	-5.7% -4.4%
Racine	-3.0% 2.2%	-5.0% -0.8%
Sheboygan	-2.5% 4.6%	-1.2% -3.0%
Mean	0.95%	-5.18%
Range	-5.3% to 9.6%	-13.1% to 1.9%

## Residential Land

Within the coastal zone of Racine County over 2,700 residential structures were identified on 660 acres (267 ha) of land. Of the total were 1,848 residential units (single family or duplexes), 745 detached garages, 110 sheds and 4 barns. Since the 1992 photos are "leaves-on," these numbers likely underestimate the actual number of structures and area devoted to residential uses. In 1978, 648 acres (263 ha) of residential land was measured. The 12 acres (4.9 ha) of residential land represents an increase of 1.9%.

Seven (7) medium to high-rise, multi-family residential units covered 12.2 acres (4.9 ha) of area in 1992 compared to 4.1 acres (1.7 ha) in 1978. Five (5) low-rise multi-family residential units covered 5.4 acres (2.2 ha) of land in 1992, an increase from 1.2 acres (.5 ha) in 1978.

## Commercial and Industrial Land

Commercial land represented 173 acres (66 ha) in 1978 and 187 acres (76 ha) in 1992. One hundred fifty-nine (159) commercial structures were noted within the 1992 coastal zone. The types central business district and neighborhood business district totaled 52 acres (21 ha) in 1978 and 57 acres (23 ha) in 1992. While no CBD entry was made on the 1978 summary sheet, it is likely that such land was misclassified and entered as neighborhood business district.

Industrial land covered 124 acres (50 ha) and 57 acres (23 ha) in 1978 and 1992, respectively. Photo scale anomalies could account for some of the reported 67 acre (27.1 ha) loss. However, the industrial type includes "grounds" used for outside storage of materials, which given the nature of industrial parks, could have changed the appearance of such land during the 14 year period.

## Transportation Land

Thirty six (36) structures were located on 123 acres (50 ha) of transportation land in 1992. In 1978, 54 acres (22 ha) of transportation land were reported, 69 acres (28 ha) fewer than reported in 1992. Most of the land use types within the transportation category experienced modest gains or losses of area over the 14 year period of the study. Public boating facilities, however, increased by 56 acres (23 ha) or 1,167%, from 4.8 acres (1.9 ha) in 1978 to 61 acres (25 ha) in 1992.

## Extractive

No extractive land of any type was observed for either year of study.

## Agricultural and Natural Land

Overall, 66 acres (27 ha) of agricultural and natural lands were reported lost from 1978 to 1992, a trend that continues nationally. Land actively being cultivated declined by 112 acres (45 ha) or by 71%. Both abandoned fields and forest lands increased in area by 47 (19 ha) and 26 acres (10.5 ha), respectively. While such a trend would be expected, given farmland abandonment, the magnitude of these increases reflects as well, the impact of the 1992 "leaves-on" photography.

Areas of shore erosion, or slump zone decreased from 53 acres (21 ha) in 1978 to 43 acres (17.5 ha) in 1992. This decrease can be explained in part by the increase of revetment construction over the same period (see below).

Also of note is a 16.6 acre (6.7 ha) decline of wetland types. The loss could be actual and attributed to both urban development and the nine (9) inch rise in Lake Michigan water level. However, a portion of the loss could be attributed to the underestimation of wetlands while using "leaves-on" photos.

## Open/Other Land

Open/other land uses were estimated to cover 155 acres (63 ha) and 140 acres (57 ha) in 1978 and 1992, respectively. Both land use types identified lost area from 1978 to 1992. Urban open lots declined from 21.5 acres (8.7 ha) to 19.6 acres (7.8 ha) while outdoor recreation land declined from 133 acres (54 ha) to 120 acres (49 ha).

## Shoreline Modifications

Sea walls and revetments are used to protect shorelines from erosion. In 1978, 5,894 feet (1,797 m) of sea wall were reported compared to 4,135 feet (1,261 m) in 1992, representing a decrease of 1,759 feet (536 m). Although not verified, the loss may represent a shift to revetment construction. However, more significant is the 9,382 foot (2,860 m), 32% increase in revetment development since 1978. Shoreline revetment was estimated at 29,582 feet (9,019 m) in 1978 and 38,964 feet (11,879 m) in 1992.

The development of groins and non-flow-through docks has increased considerably since 1978. Thirty-three (33) groins were counted in 1978, that number had increased to 60 groins by 1992. The 27 new groins represent an 82% increase. Eleven (11) non-flow-through docks were recorded in 1978 compared to 17 such docks in 1992.

## Results by Community

### Town of Caledonia

Land within Caledonia's coastal zone was measured at 492 acres (199 ha) in 1978 and 479 acres (194 ha) in 1992. The difference of 13 acres (5.3 ha) represents 2.6%. The source of the difference could be photo scale anomalies as discussed above.

In 1992, 473 residential structures were located on 128 acres (52 ha) of land. Most of these structures (277) were single family or duplex while 157 and 36 were detached garages and sheds, respectively. In 1978, 122 acres (50 ha) of residential were reported.

The commercial category displayed a modest loss over the study period, the most significant being a 6 acre (2.4 ha) decrease in institutional land. No industrial land was observed for either year of study.

The transportation category remained stable at about 15 acres (6.1 ha) from 1978 to 1992. Six (6) structures were counted, all falling in utilities.

No extractive areas were noted on either photo year.

Agricultural and natural areas, too, remained stable from 1978 to 1992. Approximately 286 acres (116 ha) were recorded for both years. However, considerable change occurred within the types of this category of land uses. Abandoned field added 64 acres (26 ha), from 74 acres (30 ha) in 1978 to 138 acres (56 ha) in 1982. Forest also increased in area, from 66 acres (27 ha) to 84 acres (34 ha).

Active agricultural land, an important type, lost nearly 74% of the 1978 base, falling from 106 acres (43 ha) to 28 acres (11 ha). Wetlands also declined in area, from 13 acres (5.3 ha) in 1978 to 7.1 acres (2.9 ha) in 1992.

Open/other land decreased from 23 acres (9.2 ha) in 1978 to 10 acres (4 ha) in 1992. Most of the loss was observed in the urban open lot type which fell from 21.5 acres (8.7 ha) to 9.5 acres (3.8 ha). The decline in open lot area shows that the process of "infilling" for development space is occurring within the township.

From 1978-1992, significant shoreline modification has occurred within Caledonia. Sea wall construction increased by 515 feet (157 m) or 122%, from 421 feet (128 m) to 936 feet (286 m). Likewise, revetment construction increased from 4,571 feet (1,394 m) to 6,655 feet (2,029 m), an increase of 2,084 feet (635 m) or nearly 46%.

Groin construction added 12 structures to the town's shoreline over the 14 year study period. In 1978, (4) groins were observed compared to 16 groins in 1992.

### Town of Mount Pleasant

Coastal zone area within the township was measured at 289 acres (117 ha) in 1978 and 273 acres (110 ha) in 1992, a

difference of 16 acres (6.5 ha) or 5.5%. The town of Mount Pleasant was one of those tested for linear accuracy of photo coverage. Using USGS maps at 1:24000, measurements taken from the 1978 photos deviated by +2.2% from the USGS basis. The 1992 photos deviated by -.8% from the USGS basis.

In 1992, a total of 669 residential structures were identified on 140 acres (57 ha) of residential land. Included were 423 single family/duplex units, 208 detached garages, 36 sheds and (2) barns. Residential land occupied 126 acres (51 ha) in 1978.

In 1992, 27 commercial structures, including one (1) institutional building, were located on 20.5 acres (7.3 ha) of commercial land. The total area represents a modest increase over 1978. Industrial land decreased from 61 acres (25 ha) in 1978 to 56 acres (23 ha) in 1992. Rather than actual, the modest loss may reflect changes to surrounding lands associated with industrial land, such modification of the landscape can mislead the photo interpreter.

Little change in land use occurred within the transportation category. Total area of transportation types was recorded as 12.5 acres (5.1 ha) in 1978 and 10.6 acres (4.3 ha) in 1992. No extractive types were observed for either study year.

Agricultural and natural areas decreased from 73 acres (29 ha) to 44 acres (18 ha) for the period studied, a loss of 29 acres (11.7 ha) or 40%. Other changes include a 6.4 acre (2.6 ha) decrease in abandoned field, a 10.5 acre (4.3 ha) decrease in active agricultural land, a 6.1 acre (2.5 ha) decrease in forest land and a 5.5 acre (2.2 ha) decrease in slump zone area.

In the category open/other land, about 2 acres (.8 ha) of outdoor recreation area were added since 1978.

Results indicate a loss of 195 feet (59 m) of sea wall. These results likely represent masking by leaves and shadows rather than actual losses of sea wall. Revetments, however, experienced considerable growth since 1978. In 1978, 6,323 feet (1,928 m) of revetment were recorded compared to 8,892 feet (2,711) in 1992, an increase of 2,569 feet (783 m) or 41%.

Whereas 20 groins were observed in 1978, only (4) were observed in 1992.

#### Village of North Bay

For both 1978 and 1992, only about 35 acres (14.1 ha) of coastal zone were recorded within the village of North Bay. For both years, most coastal zone land was devoted to residential use, 30 acres (12 ha) in 1992. In 1992, 60 single family/duplex structures were located on residential land. No significant results were recorded in any other land use category.

Some shoreline modification has occurred within the village since 1978. Revetment construction increased from 485 feet (148 m) in 1978 to 945 feet (288 m) in 1992, an increase of 460 feet (140 m) or 95%. No groins were counted in 1978, however, (6) groins were tallied in 1992.

## City of Racine

In 1978, a total of 553 acres (224 ha) comprised the coastal zone of the city of Racine. In 1992, 546 acres (221 ha) were located within the coastal zone.

Residential land encompassed 214 acres (87 ha) in 1992, which represents but a modest decrease from the 1978 residential area of 225 acres (91 ha). Land devoted to single family/duplex use covered 201 acres (81 ha) in 1992. A total of 1,271 structures were associated with this residential land, including 879 single family/duplex units, 364 detached garages, 18 sheds and (1) barn. In 1992, seven (7) structures on 12.2 acres (4.9 ha) of area were devoted to medium to high rise multi-family use while (2) structures on 1.2 acres (.5 ha) of area were devoted to low rise multi-family use.

Commercial area experienced a 28 acre (11.4 ha) increase, from 87 acres (35 ha) in 1978 to 115 acres (47 ha) in 1992. The total of CBD and neighborhood business district remained stable at about 37 acres (15 ha) for both years. However, land devoted to institutional use increased from 49 acres (20 ha) in 1978 to 77 acres (31 ha) in 1992. The increase represents 28 acres (11.3 ha) or 57%.

Results point to a dramatic drop of industrial land, from 62 acres (25 ha) in 1978 to less than 1 acre in 1992. However, transportation land experienced a significant increase in area, from 40 acres (16 ha) in 1978 to 96 acres (39 ha) in 1992. Most of the 56 acre (23 ha) gain benefit public and private boating facilities. Total land devoted to these types rose from 10.1 acres (4.1 ha) in 1978 to 74 acres (30 ha) in 1992. No extractive uses were observed for either study year.

Agricultural and natural lands covered 52 acres (21 ha) in 1978 and 34 acres (14 ha) in 1992, representing a loss of 18 acres (7.3 ha) or 34%. Most area losses were experienced within the types active agricultural land, slump zone, and wetlands.

Both 1978 and 1992 had about 86 acres (35 ha) of open/other land within the coastal zone.

Shoreline modifications increased by 12.9% (2,063 feet [629 m]) during the 14 year period studied. Sea walls decreased from 2,219 feet (674 m) to 1,931 feet (589 m) during the period, however, revetment construction increased considerably, from 13,772 feet (4,199 m) to 16,116 feet (4,914 m). Marked increases of groins and non-flow-through docks also were observed. In 1978, (5) groins were counted, the total rose to 19 groins by 1992, a 280% increase. No non-flow-through docks were observed in 1978 while (9) were observed in 1992.

## Village of Wind Point

The coastal zone of the village of Wind Point was determined to be 279 acres (113 ha) in 1978 and 256 acres (104 ha) in 1992. The 23 acre (9.3 ha) difference is 8.2% of the 1978 total.

The amount of residential land located within the coastal zone remained stable from 1978 to 1992 at about 145 acres (59 ha). Within the residential area were counted 242 structures, 209 of which were identified to be single family/duplex. Other structures included 12 detached garages, 20 sheds and (1) barn.

Commercial land remained stable over the period at about 12 acres (4.9 ha) for each study year. Land devoted to communication, a type of the transportation category, remained unchanged at about (2) acres (.8 ha) for each study year. No industrial or extractive land was identified in 1978 or 1992.

In 1978, agricultural and natural land uses covered 79 acres (32 ha) compared to 51 acres (21 ha) in 1992. The loss of about 28 acres (11 ha) represents 35.4% of the 1978 base. Four types (abandoned field, active agricultural, slump zone, and wetland) experienced significant losses while forest land experienced a marked gain in area. Abandoned field fell from 26 acres (10.7 ha) in 1978 to 15.6 acres (6.3 ha) in 1992, a loss of 10.7 acres (4.3 ha) or 41%. Likewise, active agricultural land declined from 24.6 acres (10 ha) to 10 acres (4 ha), a loss of 14.6 acres (5.9 ha) or 59%. Other reductions observed included slump zone, from 10.9 acres (4.4 ha) to 2.6 acres (1.1 ha), and wetland, from 11 acres (4.5 ha) to 3.7 acres (1.5 ha). These areas lost 76% and 66% of their 1978 base, respectively.

From 1978 to 1992, open/other land uses remained stable at about 43 acres (17.4 ha). Almost all of these acres were devoted to outdoor recreational area.

The village of Wind Point experienced significant shoreline modification development during the period studied. The data shows that sea walls declined by 1,800 feet (549 m), from 2,330 feet (710 m) in 1978 to 530 feet (162 m) in 1992. However, revetment increased by 1,925 feet (587 m) during the same period, from 4,431 feet (1,351 m) to 6,356 feet (1,938 m). Construction of groins added 14 new structures for a total of 18 groins in 1992. Eleven (11) non-flow-through docks were recorded in 1978 compared to (8) in 1992.

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**APPENDIX**

**Lake Michigan Coastal Development Inventory Project:  
1978 - 1992**

**County Summary Data Sheet**

Year: 1978  
County: Racine  
Coastal Civil Jurisdiction included in summary (in alphabetical order).

Town of Caledonia  
Town of Mt. Pleasant  
Village of North Bay  
City of Racine  
Village of Wind Point

**LAND USE CATEGORIES**

	<u><b>Area</b></u>		
	<u><b># of structures</b></u>	<u><b>Acres</b></u>	<u><b>Hectares</b></u>
<u><b>11 Residential</b></u>			
111 Res. units	4	4	2
garages			
sheds			
112 Res. units	1	1	1
garages			
sheds			
113 Res. units	1753	643	260
garages	680		
sheds	203		
barns	4		
115 Res. units			
garages			
sheds			
Subtotal	2645	648	263
<u><b>12 Commercial</b></u>			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist	112	52	21
126 Institutional	35	111	45
Subtotal	147	173	66
<u><b>13 Industrial</b></u>			
138 Industrial Park	54	124	50

	<u># of structures</u>	<u>Area</u> <u>Acres</u>	<u>Hectares</u>
<u>14 Transportation</u>			
141 Air Transportation			
142 Rail Transportation		7	3
143 Water Transportation			
143.1 Private Marina	2	5	2
143.2 Public Boat Landing	1	5	2
144 Highways		16	6
145 Communications	9	3	1
146 Utilities	4	7	3
147 Sewage Treatment Plant	13	12	5
148 Landfill			
Subtotal	29	54	22

17 Extractive

171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			

18 Agricultural and Natural

181 AF Abandoned Field		152	62
182 AG Agriculture Active		158	64
183 F Forest		88	36
184 H Heath			
185 OW Open Water		9	3
186 RL Rock Ledge			
187 SL Slump Zone		53	21
188 WT Wetland		30	12
Subtotal		489	198

19 Open Land, Other

191 Outdoor-Public Assembly			
192 Urban Open Lots	1	22	9
193 Outdoor Recreation		133	54
194 Cemeteries			
Subtotal	1	155	63

Total Acres 1649  
Total Hectares 668

Shoreline Modifications

		Linear	
		Feet	Meters
195 Sea Walls		5894	1797
196 Revetments		29582	9019
197 Groins	# of Groins	33	
198 Dock Non-Flow-Through	# of Docks	11	

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

County Summary Data Sheet

Year: 1992  
County: Racine  
Coastal Civil Jurisdiction included in summary (in alphabetical order).

Town of Caledonia  
Town of Mt. Pleasant  
Village of North Bay  
City of Racine  
Village of Wind Point

LAND USE CATEGORIES

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<u>11 Residential</u>			
111 Res. units	7	12	5
garages			
sheds			
112 Res. units	5	5	2
garages			
sheds			
113 Res. units	1848	643	260
garages	745		
sheds	110		
barns	4		
115 Res. units			
garages			
sheds			
Subtotal	2719	660	267
<u>12 Commercial</u>			
121 Central Business Dist	65	31	13
122 Shopping Center/Mall			
124 Neighborhood Business Dist	37	26	11
126 Institutional	57	129	52
Subtotal	159	187	76
<u>13 Industrial</u>			
138 Industrial Park	6	57	23

		Area	
	<u># of structures</u>	<u>Acres</u>	<u>Hectares</u>
<u>14 Transportation</u>			
141 Air Transportation			
142 Rail Transportation		4	2
143 Water Transportation			
143.1 Private Marina	8	13	5
143.2 Public Boat Landing	6	61	25
144 Highways		17	7
145 Communications	5	2	1
146 Utilities	6	15	6
147 Sewage Treatment Plant	11	13	5
148 Landfill			
	<u>Subtotal</u>	<u>123</u>	<u>50</u>

17 Extractive

171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			

18 Agricultural and Natural

181 AF Abandoned Field		199	81
182 AG Agriculture Active		46	19
183 F Forest		114	46
184 H Heath			
185 OW Open Water		7	3
186 RL Rock Ledge			
187 SL Slump Zone		43	18
188 WT Wetland		14	5
Subtotal		423	171

19 Open Land, Other

191 Outdoor-Public Assembly			
192 Urban Open Lots	1	20	8
193 Outdoor Recreation	6	120	49
194 Cemeteries			
Subtotal	7	140	57

Total Acres 1590  
Total Hectares 643

Shoreline Modifications

		Linear	
		Feet	Meters
195 Sea Walls		4135	1261
196 Revetments		38964	11879
197 Groins	# of Groins	60	
198 Dock Non-Flow-Through	# of Docks	17	

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1978  
County: Racine  
Township, Village or City name: Town of Caledonia  
PLSS section data sheets included in summary (give full description):

T4N R23E SEC 6  
SEC 7  
SEC 8  
SEC 16  
SEC 17  
SEC 21

LAND USE CATEGORIES

		Area	
	<u># of structures</u>	<u>Acres</u>	<u>Hectares</u>
<u>11 Residential</u>			
111 Res. units			
garages			
sheds			
112 Res. units	1	1	<1
garages			
sheds			
113 Res. units	254	121	49
garages	112		
sheds	50		
barns	1		
115 Res. units			
garages			
sheds			
Subtotal	418	122	50
<u>12 Commercial</u>			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist	5	4	2
126 Institutional	5	42	17
Subtotal	10	46	19
<u>13 Industrial</u>			
138 Industrial Park			

	<u># of structures</u>	<u>Area</u> <u>Acres</u>	<u>Hectares</u>
<u>14 Transportation</u>			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways			
145 Communications			
146 Utilities	4	16	6
147 Sewage Treatment Plant			
148 Landfill			
Subtotal	4	16	6

#### 17 Extractive

171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			

#### 18 Agricultural and Natural

181 AF Abandoned Field	74	30
182 AG Agriculture Active	106	43
183 F Forest	66	27
184 H Heath		
185 OW Open Water	1	<1
186 RL Rock Ledge		
187 SL Slump Zone	26	11
188 WT Wetland	13	5
Subtotal	285	116

#### 19 Open Land, Other

191 Outdoor-Public Assembly			
192 Urban Open Lots	1	22	9
193 Outdoor Recreation		1	1
194 Cemeteries			
Subtotal	1	23	9

Total Acres 492  
Total Hectares 199

#### Shoreline Modifications

	Linear	
	Feet	Meters
195 Sea Walls	421	128
196 Revetments	4571	1394
197 Groins	# of Groins	4
198 Dock Non-Flow-Through	# of Docks	

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1992  
County: Racine  
Township, Village or City name: Town of Caledonia  
PLSS section data sheets included in summary (give full description):

T4N R23E SEC 6  
SEC 7  
SEC 8  
SEC 16  
SEC 17  
SEC 21

LAND USE CATEGORIES

	# of structures	Area	
		Acres	Hectares
<u>11 Residential</u>			
111 Res. units			
garages			
sheds			
112 Res. units	3	4	2
garages			
sheds			
113 Res. units	277	123	50
garages	157		
sheds	36		
barns			
115 Res. units			
garages			
sheds			
Subtotal	473	128	52
<u>12 Commercial</u>			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist	1	3	1
126 Institutional	9	36	15
Subtotal	10	39	16
<u>13 Industrial</u>			
138 Industrial Park			

	<u># of structures</u>	<u>Area</u> <u>Acres</u>	<u>Hectares</u>
<u>14 Transportation</u>			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways			
145 Communications			
146 Utilities	6	15	6
147 Sewage Treatment Plant			
148 Landfill			
Subtotal	6	15	6

17 Extractive

171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			

18 Agricultural and Natural

181 AF Abandoned Field	138	56
182 AG Agriculture Active	28	11
183 F Forest	84	34
184 H Heath		
185 OW Open Water	1	1
186 RL Rock Ledge		
187 SL Slump Zone	28	12
188 WT Wetland	7	3
Subtotal	287	116

19 Open Land, Other

191 Outdoor-Public Assembly			
192 Urban Open Lots	1	10	4
193 Outdoor Recreation		1	<1
194 Cemeteries			
Subtotal	1	10	4

Total Acres 479  
Total Hectares 194

Shoreline Modifications

	Linear	
	Feet	Meters
195 Sea Walls	936	286
196 Revetments	6655	2029
197 Groins	# of Groins	16
198 Dock Non-Flow-Through	# of Docks	

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1978  
County: Racine  
Township, Village or City name: Town of Mount Pleasant  
PLSS section data sheets included in summary (give full description):

T3N R23E SEC 21  
SEC 28  
SEC 29  
SEC 32

LAND USE CATEGORIES

		Area	
	<u># of structures</u>	<u>Acres</u>	<u>Hectares</u>
<u>11 Residential</u>			
111 Res. units			
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units	392	126	51
garages	175		
sheds	75		
barns			
115 Res. units			
garages			
sheds			
Subtotal	642	126	51
<u>12 Commercial</u>			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist	27	11	4
126 Institutional	3	7	3
Subtotal	30	17	7
<u>13 Industrial</u>			
138 Industrial Park	25	61	25

	<u># of structures</u>	<u>Area</u> <u>Acres</u>	<u>Hectares</u>
<u>14 Transportation</u>			
141 Air Transportation			
142 Rail Transportation		4	2
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways		9	4
145 Communications			
146 Utilities			
147 Sewage Treatment Plant		<1	<1
148 Landfill			
Subtotal		13	5

17 Extractive

171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			

18 Agricultural and Natural

181 AF Abandoned Field	28	11
182 AG Agriculture Active	19	8
183 F Forest	16	7
184 H Heath		
185 OW Open Water		
186 RL Rock Ledge		
187 SL Slump Zone	10	4
188 WT Wetland	<1	<1
Subtotal	73	29

19 Open Land, Other

191 Outdoor-Public Assembly		
192 Urban Open Lots		
193 Outdoor Recreation		
194 Cemeteries		
Subtotal		

Total Acres 289  
Total Hectares 117

Shoreline Modifications

	Linear	
	Feet	Meters
195 Sea Walls	932	284
196 Revetments	6323	1928
197 Groins	# of Groins	20
198 Dock Non-Flow-Through	# of Docks	

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1992  
County: Racine  
Township, Village or City name: Town of Mount Pleasant  
PLSS section data sheets included in summary (give full description):

T3N R23E SEC 21  
SEC 28  
SEC 29  
SEC 32

LAND USE CATEGORIES

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<u>11 Residential</u>			
111 Res. units			
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units	423	140	57
garages	208		
sheds	36		
barns	2		
115 Res. units			
garages			
sheds			
Subtotal	669	140	57
<u>12 Commercial</u>			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist	26	17	7
126 Institutional	1	4	2
Subtotal	27	21	7
<u>13 Industrial</u>			
138 Industrial Park	6	56	23

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<u>14 Transportation</u>			
141 Air Transportation			
142 Rail Transportation		4	2
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways		7	3
145 Communications			
146 Utilities			
147 Sewage Treatment Plant		<1	<1
148 Landfill			
Subtotal		11	4

17 Extractive

171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			

18 Agricultural and Natural

181 AF Abandoned Field		21	9
182 AG Agriculture Active		8	3
183 F Forest		10	4
184 H Heath			
185 OW Open Water			
186 RL Rock Ledge			
187 SL Slump Zone		4	2
188 WT Wetland		<1	<1
Subtotal		44	18

19 Open Land, Other

191 Outdoor-Public Assembly			
192 Urban Open Lots			
193 Outdoor Recreation	1	2	1
194 Cemeteries			
Subtotal	1	2	1

Total Acres 273  
Total Hectares 110

Shoreline Modifications

		Linear	
		Feet	Meters
195 Sea Walls		737	225
196 Revetments		8892	2711
197 Groins	# of Groins	4	
198 Dock Non-Flow-Through	# of Docks		

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1978  
County: Racine  
Township, Village or City name: Village of North Bay  
PLSS section data sheets included in summary (give full description):

T4N R23E SEC 33  
SEC 34

LAND USE CATEGORIES

	# of structures	Area Acres      Hectares	
<u>11 Residential</u>			
111 Res. units			
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units	50	34	14
garages	5		
sheds	4		
barns			
115 Res. units			
garages			
sheds			
Subtotal	59	34	14
<u>12 Commercial</u>			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist			
126 Institutional			
Subtotal			
<u>13 Industrial</u>			
138 Industrial Park			

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<u>14 Transportation</u>			
141 Air Transportation	_____		
142 Rail Transportation	_____		
143 Water Transportation	_____		
143.1 Private Marina	_____		
143.2 Public Boat Landing	_____		
144 Highways	_____		
145 Communications	_____		
146 Utilities	_____		
147 Sewage Treatment Plant	_____		
148 Landfill	_____		
	<u>Subtotal</u>		

17 Extractive

171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
	Subtotal		

18 Agricultural and Natural

181 AF Abandoned Field	<1	<1
182 AG Agriculture Active		
183 F Forest		
184 H Heath		
185 OW Open Water	<1	<1
186 RL Rock Ledge		
187 SL Slump Zone	<1	<1
188 WT Wetland	<1	<1
	Subtotal	1 <1

19 Open Land, Other

191 Outdoor-Public Assembly		
192 Urban Open Lots		
193 Outdoor Recreation		
194 Cemeteries		
	Subtotal	

Total Acres 35  
Total Hectares 14

Shoreline Modifications

	Linear	
	Feet	Meters
195 Sea Walls		
196 Revetments	485	148
197 Groins	# of Groins	
198 Dock Non-Flow-Through	# of Docks	

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1992  
County: Racine  
Township, Village or City name: Village of North Bay  
PLSS section data sheets included in summary (give full description):

T4N R23E SEC 33  
SEC 34

LAND USE CATEGORIES

	# of structures	Area	
		Acres	Hectares
<u>11 Residential</u>			
111 Res. units			
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units	60	30	12
garages	4		
sheds			
barns			
115 Res. units			
garages			
sheds			
Subtotal	64	30	12
<u>12 Commercial</u>			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist			
126 Institutional			
Subtotal			
<u>13 Industrial</u>			
138 Industrial Park			

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<u>14 Transportation</u>			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways			
145 Communications			
146 Utilities			
147 Sewage Treatment Plant			
148 Landfill			
	Subtotal		

<u>17 Extractive</u>			
171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
	Subtotal		

<u>18 Agricultural and Natural</u>			
181 AF Abandoned Field	1	1	
182 AG Agriculture Active			
183 F Forest			
184 H Heath			
185 OW Open Water	<1	<1	
186 RL Rock Ledge			
187 SL Slump Zone	4	2	
188 WT Wetland			
	Subtotal	6	2

<u>19 Open Land, Other</u>			
191 Outdoor-Public Assembly			
192 Urban Open Lots			
193 Outdoor Recreation			
194 Cemeteries			
	Subtotal		

Total Acres 35  
Total Hectares 14

<u>Shoreline Modifications</u>		<u>Linear</u>	
		<u>Feet</u>	<u>Meters</u>
195 Sea Walls			
196 Revetments		945	283
197 Groins	# of Groins	6	
198 Dock Non-Flow-Through	# of Docks		

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1978

County: Racine

Township, Village or City name: City of Racine

PLSS section data sheets included in summary (give full description):

T3N R23E SEC 4  
SEC 9  
SEC 16  
SEC 21

T4N R23E SEC 33

LAND USE CATEGORIES

	<u># of structures</u>	<u>Area</u> <u>Acres</u>	<u>Hectares</u>
<u>11 Residential</u>			
111 Res. units	4	4	2
garages			
sheds			
112 Res. units		<1	<1
garages			
sheds			
113 Res. units	868	221	90
garages	369		
sheds	46		
barns			
115 Res. units			
garages			
sheds			
Subtotal	1287	225	91
<u>12 Commercial</u>			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist	80	37	15
126 Institutional	26	49	20
Subtotal	106	87	35
<u>13 Industrial</u>			
138 Industrial Park	29	62	25

		Area	
	<u># of structures</u>	<u>Acres</u>	<u>Hectares</u>
<u>14 Transportation</u>			
141 Air Transportation			
142 Rail Transportation		3	1
143 Water Transportation			
143.1 Private Marina	2	5	2
143.2 Public Boat Landing	1	5	2
144 Highways		7	3
145 Communications	3	1	<1
146 Utilities		7	3
147 Sewage Treatment Plant	13	12	5
148 Landfill			
	Subtotal	19	40
			16

**17 Extractive**

171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			

**18 Agricultural and Natural**

181 AF Abandoned Field	24	10
182 AG Agriculture Active	9	3
183 F Forest	2	1
184 H Heath		
185 OW Open Water	6	3
186 RL Rock Ledge		
187 SL Slump Zone	5	2
188 WT Wetland	6	2
Subtotal	52	21

**19 Open Land, Other**

191 Outdoor-Public Assembly		
192 Urban Open Lots	9	4
193 Outdoor Recreation	78	32
194 Cemeteries		
Subtotal	87	35

Total Acres 553  
Total Hectares 224

**Shoreline Modifications**

	Linear	
	Feet	Meters
195 Sea Walls	2212	674
196 Revetments	13772	4199
197 Groins	# of Groins	5
198 Dock Non-Flow-Through	# of Docks	

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1992  
County: Racine  
Township, Village or City name: City of Racine  
PLSS section data sheets included in summary (give full description):

T3N R23E SEC 4	T4N R23E SEC 33
SEC 9	SEC 34
SEC 16	
SEC 21	

LAND USE CATEGORIES

	<u># of structures</u>	<u>Area</u> <u>Acres</u>	<u>Hectares</u>
<u>11 Residential</u>			
111 Res. units	7	12	5
garages			
sheds			
112 Res. units	2	1	1
garages			
sheds			
113 Res. units	879	201	81
garages	364		
sheds	18		
barns	1		
115 Res. units			
garages			
sheds			
Subtotal	1271	214	87
<u>12 Commercial</u>			
121 Central Business Dist	65	31	13
122 Shopping Center/Mall			
124 Neighborhood Business Dist	10	7	3
126 Institutional	46	77	31
Subtotal	121	115	47
<u>13 Industrial</u>			
138 Industrial Park		<1	<1

		Area	
	<u># of structures</u>	<u>Acres</u>	<u>Hectares</u>
<u>14 Transportation</u>			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina	8	13	5
143.2 Public Boat Landing	6	61	25
144 Highways		10	4
145 Communications			
146 Utilities			
147 Sewage Treatment Plant	11	13	5
148 Landfill			
	Subtotal	25	96
			39

17 Extractive

171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			

18 Agricultural and Natural

181 AF Abandoned Field		23	9
182 AG Agriculture Active		1	<1
183 F Forest		1	<1
184 H Heath			
185 OW Open Water		5	2
186 RL Rock Ledge			
187 SL Slump Zone		4	1
188 WT Wetland		2	1
Subtotal		34	14

19 Open Land, Other

191 Outdoor-Public Assembly			
192 Urban Open Lots		10	4
193 Outdoor Recreation	4	76	31
194 Cemeteries			
Subtotal	4	86	35

Total Acres 546  
Total Hectares 221

Shoreline Modifications

		Linear	
		Feet	Meters
195 Sea Walls		1931	589
196 Revetments		16116	4914
197 Groins	# of Groins	19	
198 Dock Non-Flow-Through	# of Docks	9	

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1978  
County: Racine  
Township, Village or City name: Village of Wind Point  
PLSS section data sheets included in summary (give full description):

T4N R23E SEC 21  
SEC 22  
SEC 27  
SEC 28

LAND USE CATEGORIES

	# of structures	Area Acres      Hectares	
<u>11 Residential</u>			
111 Res. units			
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units	189	140	57
garages	19		
sheds	28		
barns	3		
115 Res. units			
garages			
sheds			
Subtotal	239	140	57
<u>12 Commercial</u>			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist			
126 Institutional	1	13	5
Subtotal	1	13	5
<u>13 Industrial</u>			
138 Industrial Park			

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>

#### 14 Transportation

141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways			
145 Communications	6	2	1
146 Utilities			
147 Sewage Treatment Plant			
148 Landfill			
Subtotal	6	2	1

#### 17 Extractive

171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			

#### 18 Agricultural and Natural

181 AF Abandoned Field	26	11
182 AG Agriculture Active	25	10
183 F Forest	5	2
184 H Heath		
185 OW Open Water	1	1
186 RL Rock Ledge		
187 SL Slump Zone	11	4
188 WT Wetland	11	5
Subtotal	79	32

#### 19 Open Land, Other

191 Outdoor-Public Assembly		
192 Urban Open Lots		
193 Outdoor Recreation	46	19
194 Cemeteries		
Subtotal	46	19

Total Acres	279
Total Hectares	113

#### Shoreline Modifications

	<u>Linear</u>	
	<u>Feet</u>	<u>Meters</u>
195 Sea Walls	2330	710
196 Revetments	4431	1351
197 Groins	# of Groins	4
198 Dock Non-Flow-Through	# of Docks	11

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1992  
County: Racine  
Township, Village or City name: Village of Wind Point  
PLSS section data sheets included in summary (give full description):

T4N R23E SEC 21  
SEC 22  
SEC 27  
SEC 28

LAND USE CATEGORIES

		Area	
		<u># of structures</u>	<u>Acres      Hectares</u>
<u>11 Residential</u>			
111 Res. units			
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units	209	149	60
garages	12		
sheds	20		
barns	1		
115 Res. units			
garages			
sheds			
Subtotal	242	149	60
<u>12 Commercial</u>			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist			
126 Institutional	1	12	5
Subtotal	1	12	5
<u>13 Industrial</u>			
138 Industrial Park			

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>

#### 14 Transportation

141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways			
145 Communications	5	2	1
146 Utilities			
147 Sewage Treatment Plant			
148 Landfill			
Subtotal	5	2	1

#### 17 Extractive

171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			

#### 18 Agricultural and Natural

181 AF Abandoned Field	16	6
182 AG Agriculture Active	10	<1
183 F Forest	18	8
184 H Heath		
185 OW Open Water	1	<1
186 RL Rock Ledge		
187 SL Slump Zone	3	1
188 WT Wetland	4	2
Subtotal	51	21

#### 19 Open Land, Other

191 Outdoor-Public Assembly		
192 Urban Open Lots	1	<1
193 Outdoor Recreation	1	42
194 Cemeteries		17
Subtotal	1	42

Total Acres	256
Total Hectares	104

#### Shoreline Modifications

	<u>Linear</u>	
	<u>Feet</u>	<u>Meters</u>
195 Sea Walls	530	162
196 Revetments	6356	1938
197 Groins	# of Groins	18
198 Dock Non-Flow-Through	# of Docks	8

NOAA COASTAL SERVICES CENTER LIBRARY



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